# New Millennium Program
# Deep Space 1
# Micro-Electronics Systems Technologies

# Micro-Electronic Systems
## Integrated Product Development Team

The Team

&

Our Technologies

# The Micro-Electronics Systems Integrated Product Development Team

National Aeronautics and Space Administration

Jet Propulsion Laboratory

Lewis Research Center

Sandia National Labs

Air Force/ Phillips Laboratory

TRW

Lockheed Martin

MIT/ Lincoln Labs

Johns Hopkins University/ Applied Physics Lab

Hughes Telecommunications & Space

University of Southern California

Honeywell

Georgia Institute of Technology

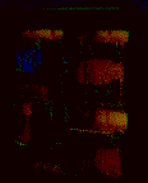
Optivision Corporation

Boeing

Goddard Space Flight Center

Irvine Sensors Corporation

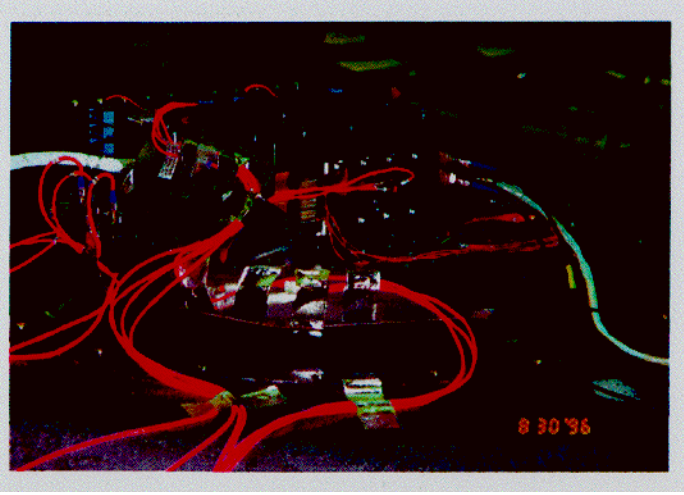
Space Computer Corporation



# Current Technologies

- 3D Stack Space Computer
- Mass Storage
- Low Power Electronics
- Power Actuation and Switching Module
- Distributed Reliable Computing

# Example of the NMP/DS1 System Architecture




JTAG Bus

PCI Bus

Temp

RS232

COP

RAD6000
+ OSC
SUROM

LMB

Local Memory

NVMM (Flash)

PCI/VME Bridge + 1773 I/F

AS1773

AS1773

Star Coupler

Star Coupler

3D Stack on VME Board

3.3 v

VME Bus

AS1773

Temp

Analog: TID

Low Power

AS1773 Rec/Tran

PCU

PASM

AS1773 Rec/Tran

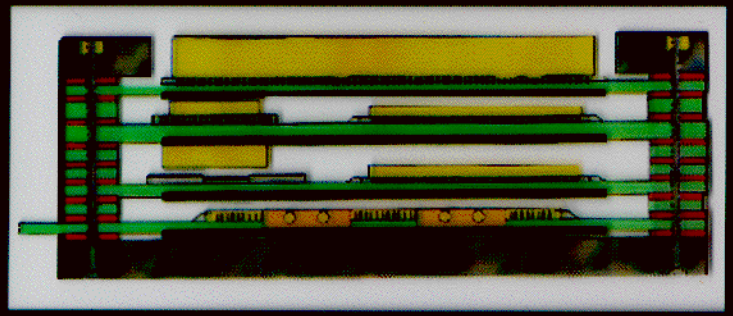
Flight Experiment

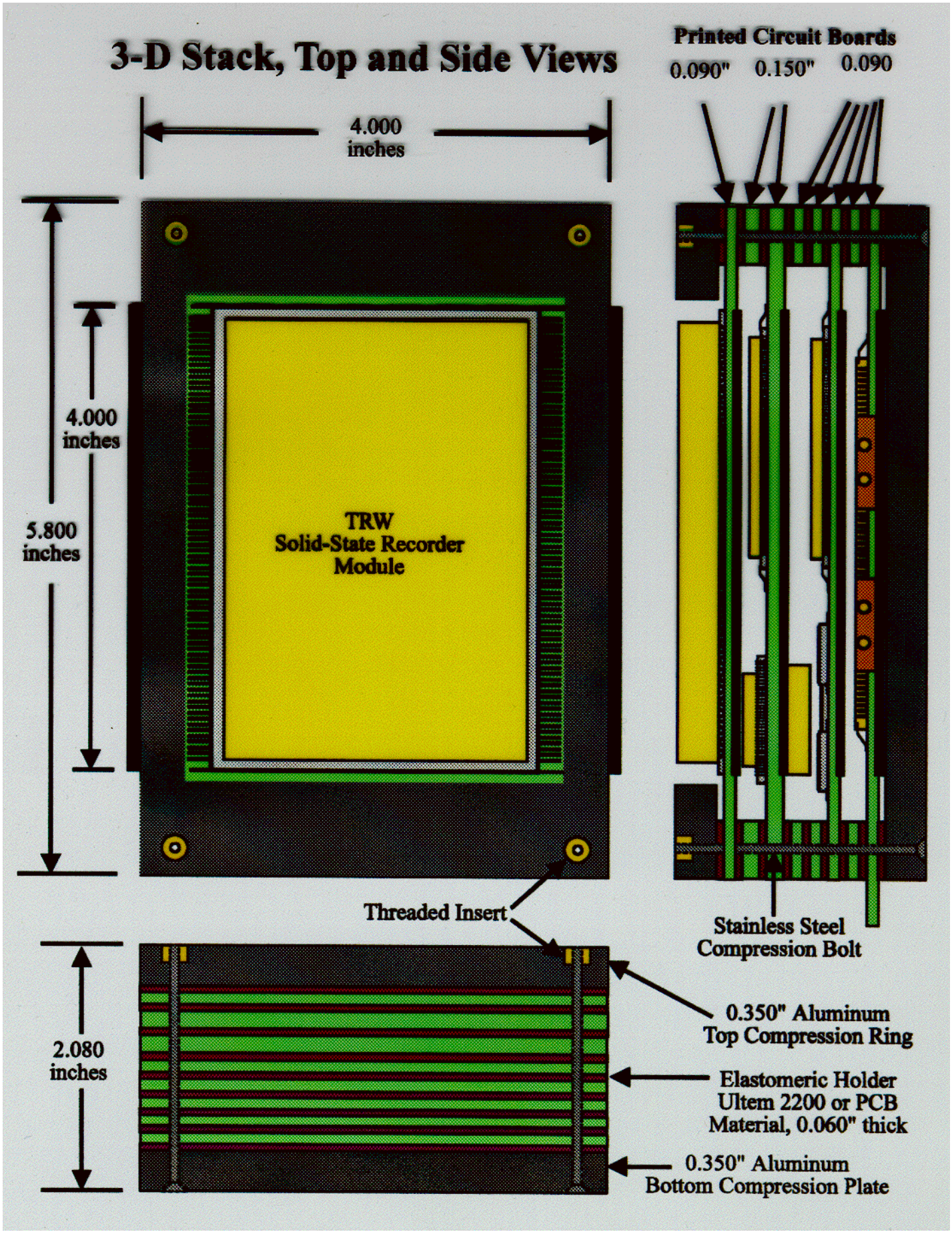
To loads

S/C 28v

# 3-D Packaging

- **Capabilities**
  - Stack of 4 MCMs (Processor, Memory, I/O, SSR)
  - 5.8" x 4.0" x 2.1"
  - 360 I/O Pads @ 32-mil Pitch
  - MCM Bonded to Substrate Holders. Substrate Holders Stacked and Connected by Elastomeric Elements
  - Re-workable Without Special Process
  - Design for Testability with Boundary Scan
- **Partnership**
  - Space Computer Corporation
- **Benefits**
  - Step Toward Direct MCM Stacking

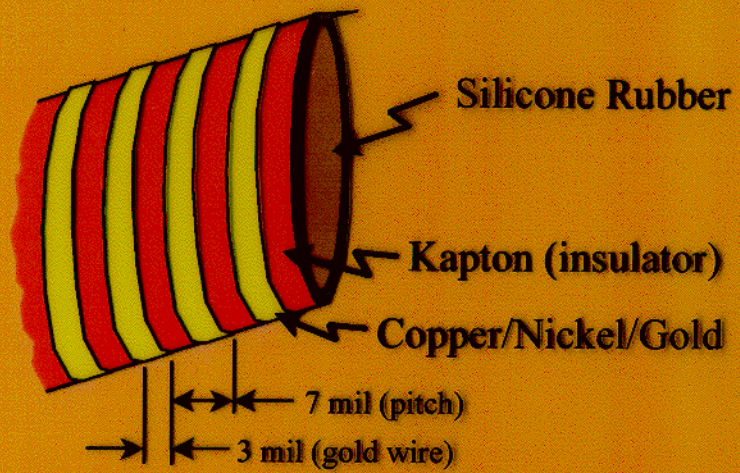



3-D Stack, Top and Side Views
Printed Circuit Boards
0.090"
0.150"
0.090
4.000
inches
4.000
inches
5.800
inches
TRW
Solid-State Recorder
Module
Threaded Insert
Stainless Steel
Compression Bolt
2.080
inches
0.350" Aluminum
Top Compression Ring
Elastomeric Holder
Ultem 2200 or PCB
Material, 0.060" thick
0.350" Aluminum
Bottom Compression Plate

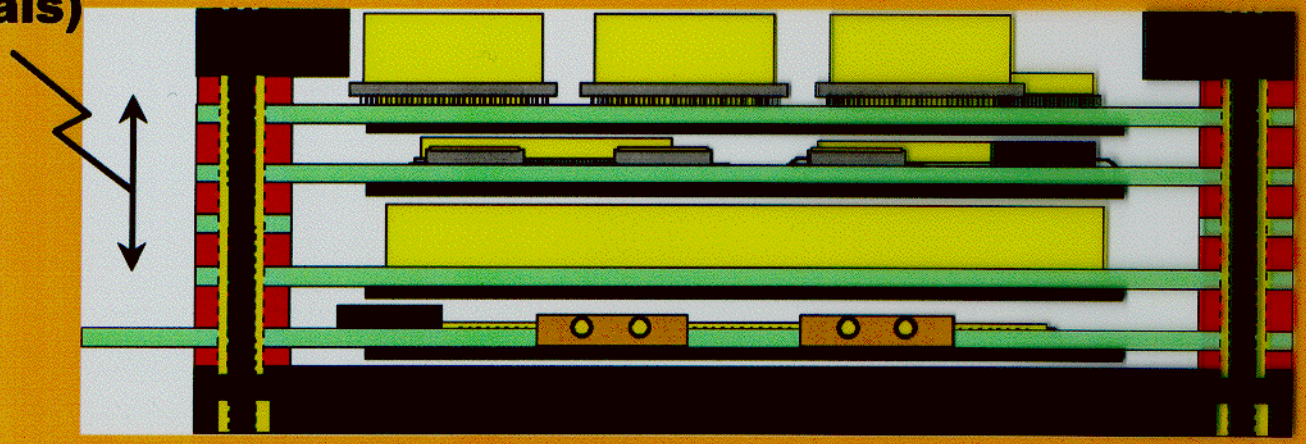
Microelectronics 3D Stack

# Elastomeric Interconnect

**The elastomer provides a highly dense interconnection mechanism between "slices" in the stack**




**Each interconnect side of the stack has 156 signals (312 total interconnect signals)**



# 3D Stack Space Computer

- 5.8" x 4.0" x 2.1" Form Factor
- 3 Dimensional Stacking of Slices
- 33 MHz Rad-6000
  - 32 Bit RISC Processor
  - Commercial PCI Interface
  - Commercial OS: VxWorks
- 320 MB DRAM
  - 100x Reduction of Mass & Volume Relative to PCB Technology
- 1773 Interface
- Point of Contact: Dwight Geer, JPL

**Memory Slice**

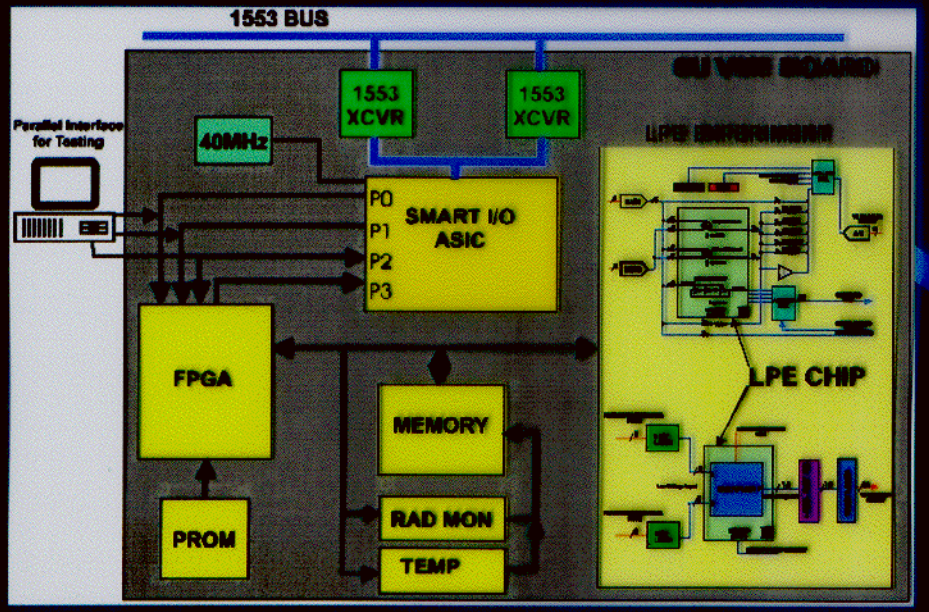
**Processor Slice**

# Mass Storage

- Non-Volatile Memory Modules
  - 1 Gigabit Storage Per Slice
  - Can Have Multiple Slices
  - All Solid State, No Moving Parts
- Point of Contact: Dwight Geer, JPL

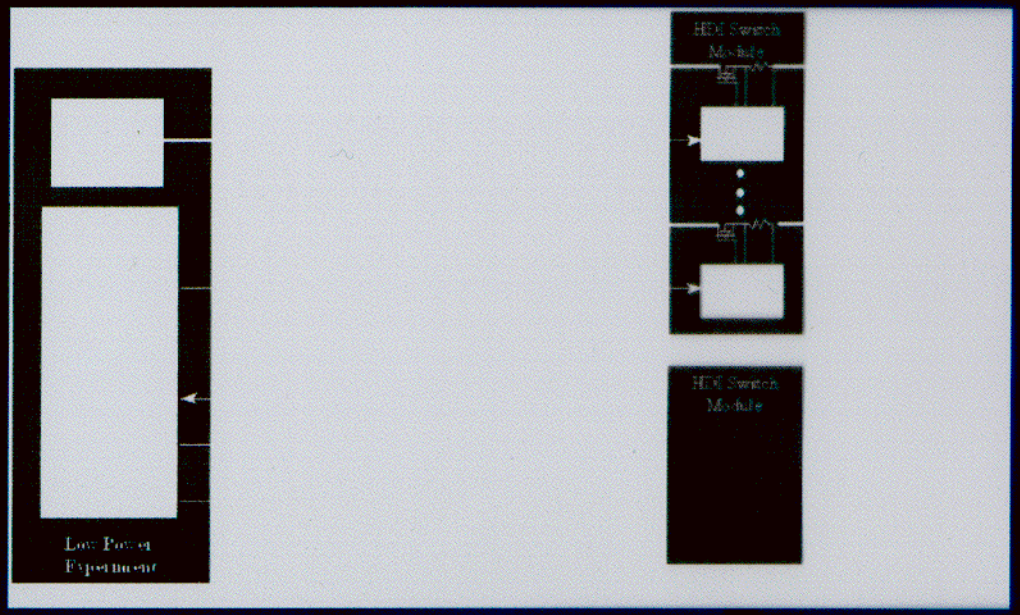
# Low Power Electronics

- .25 µm Silicon-on-Insulator CMOS
  - Extremely Low Power
  - Inherently Rad-hard
  - Capable of Extremely High Levels of Integration
  - 0.18 µm CMOS/SOI is being developed
- Point of Contact:
  - Eric Holmberg, JPL



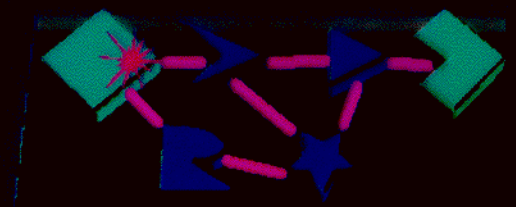
# Power Actuation and Switching Module

- High Voltage, Mixed Signal ASICs
- Uses HDI Technology
- 8 Power Switches Outputs
- Point of Contact:  Greg Carr, JPL

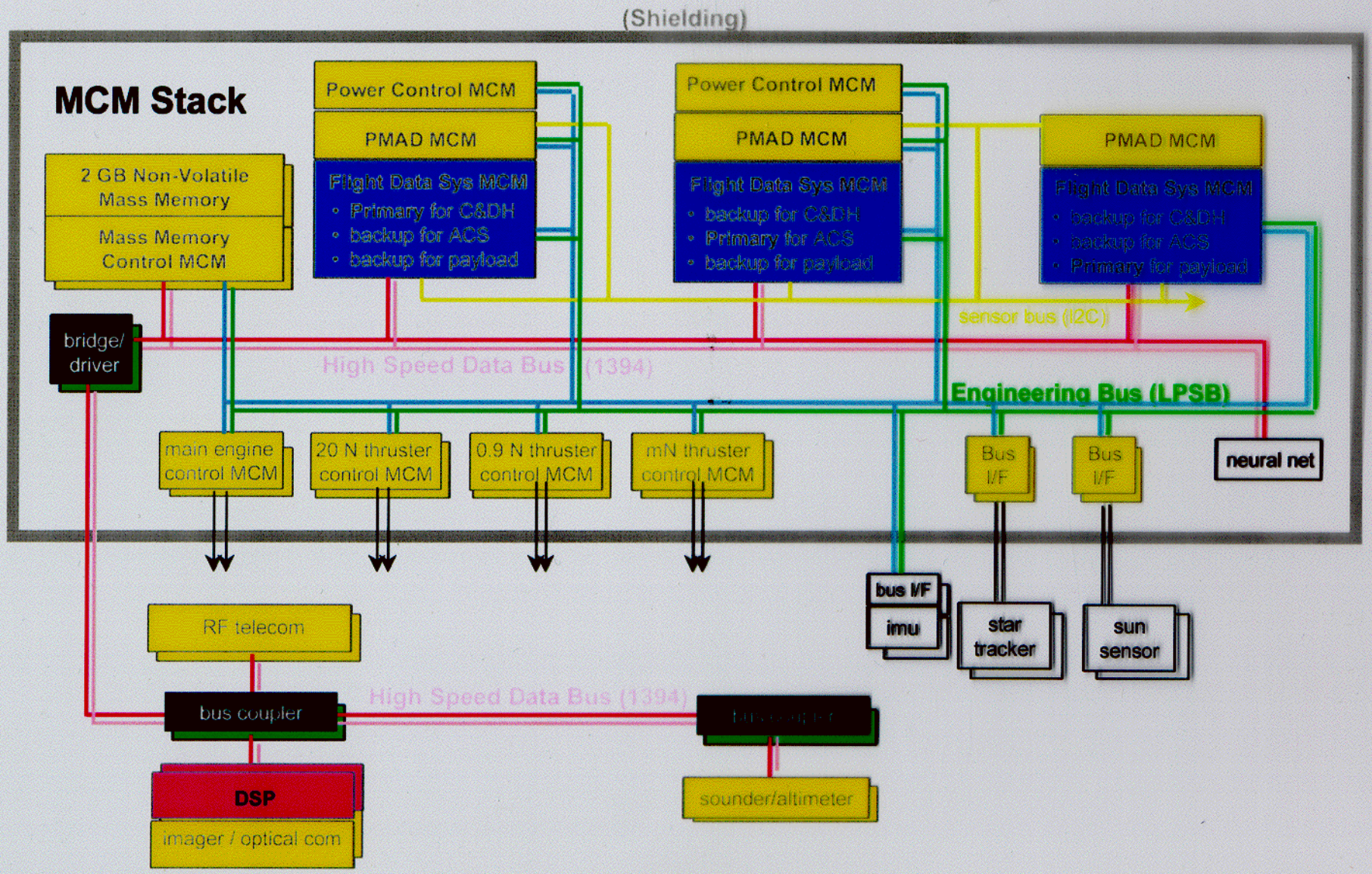


# Distributed Reliable Computing

- Commercial Off The Shelf Hardware
- Asynchronous, Message Based Application Software
- *Software Implemented Fault Tolerance* Inserted Into Message Passing System
- *Integrated I/O Architecture* Significantly Reduces Software Complexity and Performance Requirements
- *Heirarchical, Reliable Network/bus Architecture* Supporting Standard Network Protocols
- Point of Contact: David Smythe, JPL



# X2000 Avionics Architecture



# Evolution of Computers for Deep Space

*Goal: Breakthrough Increase in*
**Functional Density and **Performance*
*While Decreasing Cost, Power and Mass*

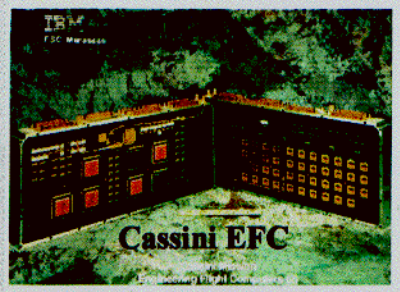
$$**rFOM = \frac{Delay \times Power}{Density}$$

Relative Figure of Merit at IC Level

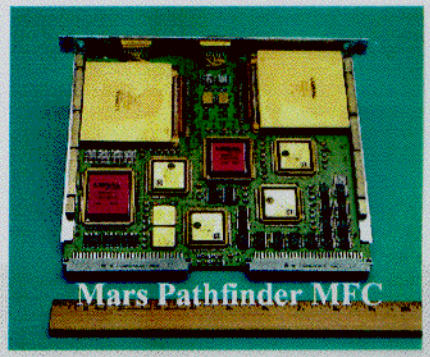
**1X$_{rFOM}$

1750 A
: 1.25 MIPS

***Functionality:*** *Command and Data Handling




**20X$_{rFOM}$

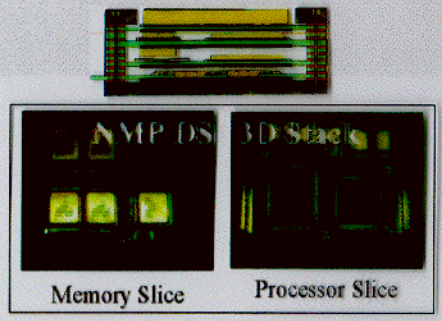



RAD6000 RISC
2.5 to 22 MIPS

***Functionality:*** *Command and Data Handling

*Attitude Determination and Control

**117X$_{rFOM}$




: RAD6000 RISC Flight Computer
2.5 to 55MIPS, very high perf. PCI and 1773 I/O, low power electronics

***Functionality:***

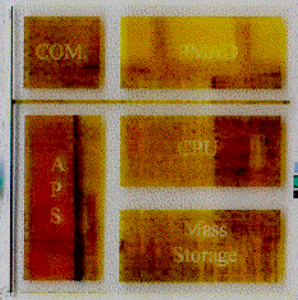
*Command and Data Handling

*Attitude Determination and Control

*Mass Storage (nonvolatile)

*Power Management & Distribution (PMAD)

**>2000X$_{rFOM}$




100s of MIPS

***Functionality:***

*Command and Data Handling

*Attitude Determination and Control

*Mass Storage

*PMAD

*Sensor electronics, mixed signal, DSP

*Telecom

*GN&C sensors and MEMS

*Evolvable system

*Reconfigurable Hardware

*Major use of IP